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(54) The use of probucol for preventing and treating heart diseases.

(57) The invention relates to the use of probucol for preventing and treating heart diseases, wherein a reduced myocardial oxygen consumption is desirable or necessary, such as cardiomyopathy of various origins, the hyperkinetic heart syndrome and coronary heart disease, including coronary insufficiency and its concomitant symptoms or secondary diseases.

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**"The Use of Probucol for Preventing and Treating Heart Diseases"**

The invention relates to the use of probucol for preventing and treating heart diseases, wherein a reduced myocardial oxygen consumption is desirable or required. Examples of such diseases are cardiomyopathy of various origins, the hyperkinetic heart syndrome and coronary heart disease, including coronary insufficiency and its concomitant symptoms or secondary diseases.

5 Concomitant symptoms of coronary insufficiency may be angina pectoris attacks, a temporary insufficiency of the myocardial contractility associated with a lessening in the force of the heart action, arrhythmias etc. Secondary diseases of coronary insufficiency may be tissue necroses with subsequent irreversible heart insufficiency, myocardial infarct, irreversible arrhythmias, etc.

10 Probucol is administered in doses of 1000 mg/day to treat certain metabolic disorders which are accompanied by increased serum cholesterol levels; see US Patent 3,862,332.

15 The US Defensive Publication No. 17,717 contains test results relating to signs of histopathological injuries, signs of cardiomyopathy, signs of tissue necrosis and signs of tissue adhesion in the case of experimentally induced trauma i.e. mechanical trauma (operation), chemical trauma (iso proterenol, cobalt, chloride) and/or pathological trauma (cardiac infarction, aortic stenosis, congenital cardiomyopathy, nephritis, damage of the liver parenchyma) and their response to probucol in mammals.

20 Changes in the heart rate, in particular under physical stress, and a positive influence on the regulation of the heart and the blood circulation and the function of the heart are not mentioned. The term "cardioprotective" is used only in connection with histopathological findings but not, as is usual in cardiology, with the function of the heart, the corresponding oxygen consumption and the coronary reserve depending on it.

25 Surprisingly, probucol has been found to have an advantageous effect on the function and performance capacity of the heart. When considering the result of ergometric testing in judging the size of the heart, clear signs can be found for the favourable influence of probucol on the regulation of the heart and the circulation in addition to its lowering of the increased serum cholesterol values. This mode of action is reflected in the changes during exercise of the heart rate, the power and oxygen utilization and the cardiac work.

**Patients and Method:**

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To examine the mode of action of probucol on the regulation of the heart and the blood circulation, 16 normal, clinically healthy males aged 20 to 40 years were administered probucol after stress and examined for stress-induced changes in the heart and the blood circulation. For this purpose, the results of six defined ergometries (gradual bi-cycle ergometry to the subjective maximum strain whilst lying down, loads each 35 increased by 50 watt and applied for 3 minutes, starting load 100 watt, EC gramm at the end of each stress minute) were collected in each case. The data from 2 tests with medication ( $2 \times 500$  mg probucol, duration of medication 4 and 8 weeks) were contrasted in an examination of the statistical significance (student's t test in paired data) with the findings of 4 control tests (4 weeks and immediately before starting the medication, 4 and 12 weeks after discontinuing the medication).

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While the findings for the individual body weight and the maximum performance capacity, the action of the heart and the heart volume at rest, the regulation and utilization of the carbohydrates before, during and after exercise remain unchanged, the administration of probucol was found to specifically influence

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- the heart rate under exercise (see Table I)
- the power (see Table II)
- the oxygen utilization (see Table III) and
- the cardiac work under exercise (see Table IV).

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Starting from almost identical heart rates in repose and comparable heart rates at moderate strain (100 watt corresponding to 40% of the maximum performance capacity, the stress-induced increase in the rate compared to the results in the control test can be reduced by 10 beats (-13%) in the submaximum range and by 15 beats (-20%) at maximum strain; this effect can already be significantly demonstrated by about 10% at intensities of around 60% of the maximum performance capacity. Moreover, without restricting the

maximum performance capacity under medication, the cardiac work, which can be measured in the product of heart rate and systolic blood pressure, is lowered by about 10%. The performance capacity of the heart, judged by the quotient formed from the power or oxygen utilization, is likewise significantly increased by about 7%.

- 5 These effects of the test substance must be acknowledged to be of so far unknown, therapeutic importance for a risk population suffering from coronary diseases. The results show that the administration of probucol makes it possible to widen the regulatory range of the heart and the blood circulatory system in submaximum and maximum performance without simultaneously reducing the maximum performance capacity. In view of the established relationship between the blood pressure heart rate product and the
- 10 oxygen consumption of the heart on the one hand and the oxygen consumption of the heart and the threshold of pain of angina pectoris on the other hand, the lowering of the blood pressure heart rate product by probucol means an improvement of the coronary reserve, and, in the case of patients suffering from coronary diseases, it also means the improvement of the performance capacity limited by symptoms. It is for these very risk patients with coronary heart diseases suffering from dyslipoproteinemia and coronary
- 15 angiopathy, that it is desirable to lower the cardiac work and the myocardial oxygen consumption, as an improvement of the coronary reserve under strain can be expected to result in a lessening of the ischemic reaction and reduced arrhythmias. Compared to other preparations which reduce the heart rate and the heart action (for instance betablockers), probucol should be especially highlighted in that it exerts this cardioprotective effect, without simultaneously affecting the maximum performance capacity and the
- 20 contractility reserve of the heart, the latter being perceptible from the former. This is all the more important for persons who can be assumed to already have a lower contractility reserve, for in this case the substance would have to be held to show an undesirable side effect, if its negatively inotropic property, which acts independently, appeared at the same time as the lowering of the heart rate.

On the basis of the results that are available on the influence of probucol on the regulation of the heart and the blood circulation, the following effects not known so far and differing from other substances are to be highlighted.

- 25 1. With defined intensities, the individual heart rate is markedly lower as from about 60% of the maximum performance capacity, while the maximum performance remains unchanged. A favourable influence is exerted on the parameters of the working heart (power, oxygen utilization, blood pressure heart rate product), while there is no sign of a lower contractility reserve.

30 2. The regulation of parameters of the heart and the blood circulation at rest remains unchanged; there are no signs of undesired blocking of the sympathoadrenergic tonus

- 35 3. Nor are there any indications that the reduced action of the heart is coupled with a simultaneous increase in the peripheral muscular strain or fatigue (glucose and lactate behaviour) or an undesired inhibitory effect on the peripheral energy supply (glucose utilization, glycogenolysis).

40 Pharmaceutical compositions containing probucol as the active ingredient can be prepared in the manner described in US Patent 3,862,332. The pharmaceutical compositions can be administered orally, or parenterally. The oral route is preferred. Typical examples of dosage unit forms are tablets and injection preparations. The dose depends on the severity of the patient's illness, on his age and weight. The daily dose may be about 2 to 20 mg, preferably 4 to 15 mg of the active ingredient per kg of bodyweight.

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Table I

Ia:...Heart\_rate\_at\_rest  
Heart rate under exercise

Test	Average value	Standard deviation	Minimum	Maximum
1	68,19	11,96	48,00	90,00
2	68,69	12,12	48,00	89,00
3	66,19	11,34	48,00	90,00
4	67,50	13,36	47,00	95,00
5	65,81	10,17	50,00	85,00
6	65,75	8,39	51,00	83,00

Reference group: test I  
 tested against:

Test	AV (Diff.)	Standard deviation	F.grade : t-Value	p <
2	0,50	9,60	15 : 0,208	0,8377
3	-2,00	9,19	15 :-0,871	0,3976
4	-0,69	12,19	15 :-0,226	0,8245
5	-2,38	9,67	15 :-0,982	0,3417
6	-2,44	9,74	15 : -1,001	0,3325

The numbers in this and the following Tables mean:

- 1 = control test 4 weeks before medication
- 2 = control test 1 day before medication
- 3 = examination after 4 weeks of medication
- 4 = examination after 8 weeks of medication
- 5 = control test 4 weeks after discontinuing the medication
- 6 = control test 12 weeks after discontinuing the medication

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Table I - continued

Ib: Load of 200 watt

Test	Average value	Standard deviation	Minimum	Maximum
1	147,27	14,86	122,00	179,00
2	145,40	16,30	120,00	173,00
3	137,75	14,26	111,00	162,00
4	137,33	14,41	117,00	164,00
5	141,63	15,51	118,00	174,00
6	143,25	15,18	108,00	173,00

Reference group: test 1  
tested against

Test	AV (Diff.)	SD (Diff.)	F.grade :	t-value	p<
2	-1,87	6,98	14	-1,036	0,3178
3	-10,00	5,44	14	-7,122	0,0000 ***
4	-9,93	8,08	14	-4,764	0,0003 ***
5	-4,87	9,11	14	-2,069	0,0575
6	-4,40	10,37	14	-1,643	0,1226

Table I - continued

Ic: Maximum load

Test	Average value	Standard deviation	Minimum	Maximum
1	170,13	14,92	140,00	195,00
2	167,56	14,50	137,00	195,00
3	155,31	11,01	135,00	177,00
4	157,25	9,66	142,00	184,00
5	165,00	14,03	130,00	185,00
6	164,63	11,52	144,00	185,00

Reference group: test 1  
tested against:

Test	AV (Diff.)	Standard deviation	F.grade	t-Value	p <
2	-2,56	5,56	15	-1,843	0,0852
3	-14,81	12,05	15	-4,919	0,0002 ***
4	-12,88	14,88	15	-3,462	0,0035 **
5	-5,13	14,17	15	-1,446	0,1682
6	-5,50	10,00	15	-2,200	0,0439 *

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Table II

Power  
IIa: Load of 100 watt

Test	Average value	Standard deviation	Minimum	Maximum
1	0,96	0,15	0,79	1,35
2	0,96	0,10	0,82	1,11
3	1,00	0,15	0,84	1,37
4	1,00	0,14	0,78	1,32
5	0,97	0,10	0,81	1,18
6	0,96	0,12	0,85	1,35

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F.grade	t-Value	P <
2	-0,01	0,09	15 :	-0,365	0,7205
3	0,04	0,12	15 :	1,212	0,2442
4	0,03	0,13	15 :	1,011	0,3282
5	0,00	0,09	15 :	0,077	0,9399
6	-0,00	0,08	15 :	-0,028	0,9782

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Table II - continued

Lib: Load of 200 watt

Test	Average value	Standard deviation	Minimum	Maximum
1	1,37	0,14	1,12	1,64
2	1,39	0,16	1,16	1,67
3	1,47	0,16	1,24	1,80
4	1,47	0,15	1,22	1,71
5	1,43	0,16	1,15	1,70
6	1,41	0,16	1,16	1,85

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F. grade	t-value	p <
2	0,02	0,07	14 :	1,144	0,2718
3	0,10	0,06	14 :	6,739	0,0000 ***
4	0,10	0,08	14 :	4,728	0,0003 ***
5	0,05	0,10	14 :	2,014	0,0637
6	0,05	0,10	14 :	1,685	0,1141

Table II - continued

Test	Average value	Standard deviation	Minimum	Maximum
1	1,51	0,27	1,12	2,19
2	1,50	0,26	1,12	2,19
3	1,61	0,26	1,24	2,33
4	1,61	0,26	1,24	2,33
5	1,56	0,21	1,15	1,88
6	1,53	0,24	1,16	2,16

Reference group: test 1  
tested against:

Test	AV (Diff.)	Standard deviation	F.grade	t-Value	P <
2	-0,01	0,06	15	-0,542	0,5956
3	0,10	0,06	15	6,192	0,0000 ***
4	0,10	0,08	15	5,251	0,0001 ***
5	0,05	0,16	15	1,177	0,2575
6	0,02	0,12	15	0,709	0,4894

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Table III  
Oxygen Utilization

IIIa: Load of 150 watt

Test	Average value	Standard deviation	Minimum	Maximum
1	16,37	1,82	13,76	19,64
2	16,53	1,89	13,31	20,85
3	17,21	2,32	14,45	23,25
4	16,98	1,78	13,95	19,64
5	16,78	1,88	13,85	20,64
6	16,50	1,74	14,34	21,07

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F.grade	t-Value	p <
2	0,17	1,08	15 :	0,612	0,5497
3	0,84	1,31	15 :	2,563	0,0216 *
4	0,61	1,25	15 :	1,951	0,0700
5	0,42	1,23	15 :	1,356	0,1951
6	0,13	0,91	15 :	0,589	0,5644

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Table III - continuedIIIb: Load of 200 Watt

Test	Average value	Standard deviation	Minimum	Maximum
1	17,75	1,78	14,47	21,23
2	18,03	2,08	14,97	21,58
3	19,00	2,03	15,99	23,33
4	19,05	1,96	15,79	22,14
5	18,49	2,02	14,89	21,95
6	18,28	2,08	14,97	23,98

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F.grade	t-Value	P <
2	0,28	0,94	14	1,138	0,2741
3	1,32	0,76	14	6,735	0,0000 ***
4	1,30	1,07	14	4,698	0,0003 ***
5	0,65	1,24	14	2,010	0,0641
6	0,59	1,36	14	1,684	0,1143

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Table III - continuedIIIc: Maximum load

Test	Average value	Standard deviation	/	Minimum	Maximum
1	19,05	3,19	14,47	26,83	
2	18,99	3,08	14,62	26,83	
3	20,35	3,07	15,99	28,62	
4	20,37	3,02	15,99	28,62	
5	19,66	2,42	14,89	23,28	
6	19,34	2,74	14,97	26,50	

Reference group: test 1  
tested against:

Test	AV (Diff.)	Standard deviation	F.grade	t-value	p <
2	-0,06	0,66	15	-0,370	0,7164
3	1,30	0,80	15	6,464	0,0000 ***
4	1,32	1,00	15	5,261	0,0001 ***
5	0,61	1,97	15	1,231	0,2372
6	0,29	1,40	15	0,829	0,4199

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**Table IV****Cardiac work****Iva: Cardiac work at rest**

Test	Average value	Standard deviation.	Minimum	Maximum
1	8,11	1,53	5,04	10,80
2	8,39	1,81	5,28	11,13
3	8,07	1,66	5,76	11,31
4	7,91	1,83	5,17	11,40
5	7,54	1,63	5,25	11,05
6	7,81	1,51	5,87	11,21

Reference group: test 1  
tested against:

Test	AV (Diff.)	Standard deviation	F.grade	t-value	p <
2	0 ,39	1,28	14	: 1,192	0,2530
3	-0 ,04	1,43	15	: -0,109	0,9143
4	-0 ,20	1,69	15	: -0,468	0,6464
5	-0 ,57	1,21	15	: -1,905	0,0761
6	-0 ,30	1,27	15	: -0,949	0,3579

55 56 46 40 35 28 25 20 15 10 5

Table IV - continuedIVb: Load of 200 watt

Test	Average value	Standard deviation	Minimum	Maximum
1	27,91	4,33	18,30	38,49
2	27,26	3,99	20,74	36,33
3	25,71	4,18	19,98	33,88
4	24,85	4,30	19,20	34,02
5	24,58	4,12	18,00	33,06
6	25,90	3,66	19,98	34,60

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F.grade	t-Value	P <
2	-0,66	3,07	14	-0,828	0,4217
3	-2,08	3,01	14	-2,670	0,0183 *
4	-3,06	2,87	14	-4,124	0,0010 **
5	-3,08	2,58	14	-4,622	0,0004 ***
6	-2,08	2,89	14	-2,779	0,0148 *

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55 50 45 40 35 30 25 20 15 10

Table IV - continued  
IYC: Maximum load

Test	Average value	Standard deviation	Minimum	Maximum
1	35,03	4,30	26,60	40,95
2	34,67	4,69	24,48	41,14
3	31,54	4,81	23,93	44,25
4	31,52	3,95	23,68	41,40
5	31,82	4,72	20,80	42,55
6	30,50	6,00	12,68	39,60

Reference group: test 1  
tested against:

Test	AV (Diff.)	SD (Diff.)	F.grade :	t-Value	p <
2	-0,36	2,64	15 :	-0,551	0,5899
3	-3,50	3,80	15 :	-3,685	0,0022 **
4	-3,51	3,20	15 :	-4,389	0,0005 ***
5	-3,22	3,64	15 :	-3,536	0,0030 **
6	-4,53	6,68	15 :	-2,716	0,0159 *

**Claims**

1. The use of probucol for the preparation of a medicament for preventing and treating heart diseases, wherein a reduced myocardial oxygen consumption is desired or necessary.
- 5 2. An embodiment according to claim 1, characterized in that the disease to be treated is the coronary heart disease, including coronary insufficiency and its consecutive symptoms or secondary diseases.
3. An embodiment according to claim 1, characterized in that the disease to be treated is cardiomyopathy of various origins and the hyperkinetic heart syndrom.

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